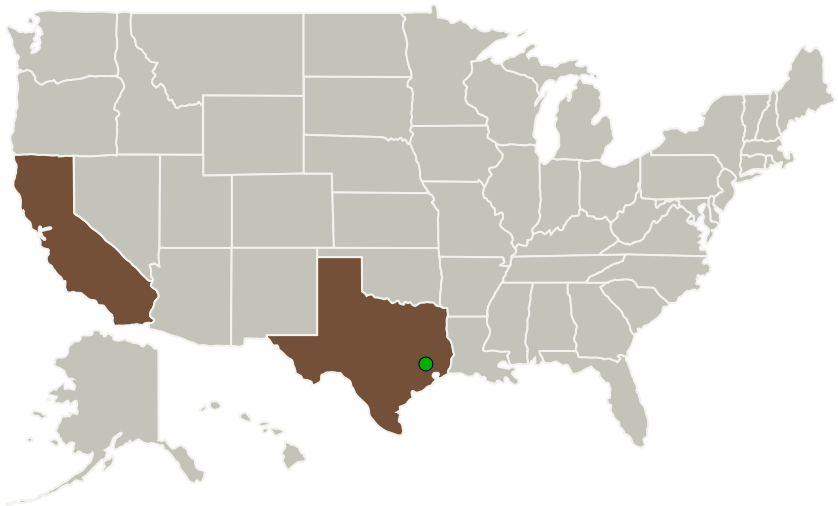
# Microchannel Methanation Reactors Using Nanofabricated Catalysts, Phase II

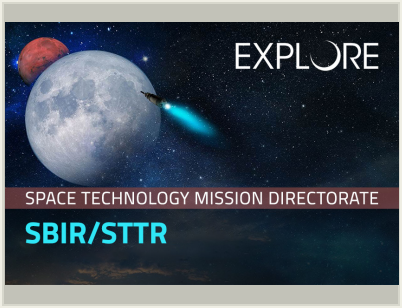
Completed Technology Project (2010 - 2012)

## Project Introduction

Makel Engineering, Inc. (MEI) and the Pennsylvania State University (Penn State) propose to develop and demonstrate a microchannel methanation reactor based on nanofabricated catalysts. Our innovative approach of combining microchannel reactor technology with nanofabricated catalysts provides the synergy between these two emerging technologies with the potential to enhance reaction efficiency by orders of magnitude. This improvement in efficiency leads to more compact and lower mass reactor systems. Thermal and mass diffusion distances in microchannel reactors range from tens to hundreds of microns versus tens to hundreds of millimeters in conventional reactors. Slow heat and mass transfer dominate the operation of conventional reactor designs, thus limiting reaction kinetics. As is well known, catalytic efficiency increases with decreasing catalyst particle size (reflecting higher surface area per unit mass) and chemical reactivity frequently is enhanced at the nanoscale. By virtue of their nanoscale dimensions, nanotubes and nanorods geometrically restrict the catalyst particle size that can be supported upon the tube walls. By confining catalyst particles to sizes smaller than the CNT diameter, a more uniform catalyst particle size distribution may be maintained. The high dispersion provided by the vast surface area of the nanoscale material serves to retain the integrity of the catalyst by reducing sintering or coalescence. To maximize catalyst exposure, our design includes hierarchical support structures, consisting of a 3-d network of open pores within the microreactor structure, and finally the nanofabricated support. Additional advantages of the hierarchical catalyst support structure include minimal pressure drop (while providing superior catalyst contact) without the need to resort to fluidized bed configurations.

## Primary U.S. Work Locations and Key Partners



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| Organizations Performing Work | Role | Type | Location |
|---|---|---|---|
| Makel Engineering, Inc. | Lead Organization | Industry<br>Small Disadvantaged Business (SDB) | Chico, California |
| Johnson Space Center(JSC) | Supporting Organization | NASA Center | Houston, Texas |

| Primary U.S. Work Locations | |
|---|---|
| California | Texas |

## Project Transitions

**February 2010:** Project Start

**September 2012:** Closed out

**Closeout Documentation:**

- Final Summary Chart*(https://techport.nasa.gov/file/139215)*

## Organizational Responsibility

**Responsible Mission Directorate:**

Space Technology Mission Directorate (STMD)

**Lead Organization:**

Makel Engineering, Inc.

**Responsible Program:**

Small Business Innovation Research/Small Business Tech Transfer

## Project Management

**Program Director:**

Jason L Kessler

**Program Manager:**

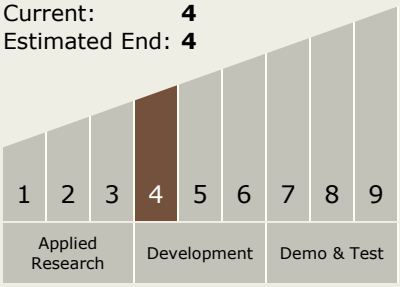
Carlos Torrez

**Principal Investigator:**

Susana Carranza

## Technology Maturity (TRL)

Start: **4**
Current: **4**
Estimated End: **4**



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## Technology Areas

**Primary:**

- TX07 Exploration Destination Systems
  - TX07.1 In-Situ Resource Utilization
    - TX07.1.3 Resource Processing for Production of Mission Consumables

## Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System